



THE
Tea Research Institute
OF
Ceylon.

BULLETIN No. 5.

Annual Report for the Year
1930.



Published by

THE TEA RESEARCH INSTITUTE OF CEYLON,
VICTORIA COMMEMORATION BUILDINGS, KANDY.

THE TEA RESEARCH INSTITUTE.



BOARD OF CONTROL.

(A) Representing the Planters' Association of Ceylon:—

- (1) Mr. R. G. Coombe (Chairman).
- (2) Mr. Jas. Forbes (Jnr.).
- (3) Mr. J. Horsfall.

(B) Representing the Ceylon Estates Proprietary Association:—

- (4) Mr. J. D. Finch Noyes.
- (5) Major J. W. Oldfield.
- (6) Major H. Scoble Nicholson, O. B. E.

(C) Representing the Low-Country Products' Association:—

- (7) The Hon. Mr. D. S. Senanayake.

(D) Representing the Small-Holders:—

- (8) Mr. T. B. Panabokke.

(E) Ex-Officio Members:—

- (9) The Hon. the Colonial Treasurer.
- (10) The Hon. the Director of Agriculture.
- (11) The Chairman, Planters' Association of Ceylon.
- (12) The Chairman, Ceylon Estates Proprietary Association.

Secretary, Mr. A. W. L. Turner, Victoria Commemoration
Buildings, Kandy.

REPORT

OF THE

BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

FOR 1930.

Foundation:—The Institute was established and the Board of Management thereof incorporated by Ordinance No. 12 of 1925, dated the 27th October, 1925.

Board of Management:—On the 1st January, 1930, the Board of Management consisted of the following Members:—

Ex-Officio Members.

The Hon'ble the Colonial Treasurer
The Director of Agriculture
The Chairman, P. A. of Ceylon
The Chairman, C. E. P. A.

P. A. of Ceylon Representatives

Mr. R. G. Coombe
Mr. John Horsfall
Mr. D. S. Cameron

C. E. P. A. Representatives.

Mr. P. A. Keiller
Mr. C. H. Figg (Acting)
Major H. Scoble Nicholson, O.B.E. (,)

L. C. P. A. Representative

The Hon'ble Mr. D. S. Senanayake, M.L.C.

Small-Holders Representative.

Mr. T. B. Panabokke.

Mr. R. G. Coombe continued as Chairman of the Board throughout the year.

During the absence of Mr. A. W. L. Turner, Secretary, T. R. I., on six months' leave, Mr. R. R. Muras was appointed Acting Assistant Secretary.

Mr. C. H. Figg, acting for Mr. J. D. Finch Noyes, resigned his appointment as from the 22nd January, prior to his departure for England and Mr. A. S. Collett was appointed in his place.

Mr. E. C. Villiers, the Chairman of the P. A., retired on the 12th March, and was succeeded by Mr. A. G. Baynham, the new Chairman.

Mr. D. S. Cameron, on his return from leave, resigned his appointment and Mr. Jas. Forbes (Jnr.) who was acting for him during his absence was confirmed in his appointment.

Mr. W. Coombe retired from the Chairmanship of the Ceylon Estates Proprietary Association on the 11th April, and was succeeded by Mr. F. F. Roe, the new Chairman.

Mr. P. A. Keiller resigned his appointment as from the 21st May, and Major H. Scoble Nicholson was appointed a permanent member of the Board.

Major J. W. Oldfield returned from leave and resumed his seat on the Board as from the 2nd December, relieving Mr. G. R. Whitby.

MEETINGS OF THE BOARD.

Four meetings of the Board were held, two in Colombo and two in Kandy. The average attendance was 9.

The Board wishes to record its thanks to the Management of the Grand Oriental Hotel, Colombo, for the loan of their Ball Room for the meetings held in Colombo.

Estate Sub-Committee:—Mr. R. G. Coombe (Chairman), Dr. R. V. Norris (Director), Major J. W. Oldfield, Mr. Jas. Forbes (Jnr.), Mr. J. E. B. Baillie-Hamilton (Acting).

This Sub-Committee held two Meetings during the year.

Experimental Sub-Committee:—The Chairman, T. R. I., the Director, T. R. I., the Agricultural Chemist, the Visiting Agent, the Superintendent of St. Coombs, Messrs. John Horsfall and C. C. du Pré Moore.

This Sub-Committee met on three occasions.

Estimates Sub-Committee:—The Chairman, T. R. I., the Director, the Superintendent, St. Coombs, Mr. F. F. Roe and Mr. John Horsfall.

This Sub-Committee met on one occasion.

T. R. I. Conference Sub-Committee:—The Chairman, T. R. I., the Director, Mr. Jas. Forbes (Jnr.) and Mr. Huntley Wilkinson.

A Joint Meeting of the Estate Sub-Committee, Estimates Sub-Committee and Experimental Sub-Committee was held on the 22nd November, at which a recommendation was made that the Sub-Committees should be re-organised and in future be known as the Finance and Experimental Sub-Committees.

BUNGALOWS AND QUARTERS FOR STAFF.

During the year the following Buildings were completed:—

- (a) **Bungalows:**—4 for Senior Staff,
1 for Junior Staff.

Two more Junior Bungalows are in course of construction, making when completed, 6 of the 10 required.

- (b) **Quarters:**—for two Clerks, as well as for Peons, Car Drivers and servants.

LABORATORIES.

The new Laboratories at St. Coombs were occupied by the Staff in December. The leases of Lindfield and Mahagalla Bungalows were terminated as from the end of 1930.

FACTORY.

A part of the small-scale experimental machinery has been erected at the Factory, the cost being provided from the vote granted by the Empire Marketing Board.

The following procedure has been approved by the Board in regard to applications for tests of Machinery or manufacturing processes to be carried out in St. Coombs Factory.

- (1) On receipt of such applications, the firm or individual concerned should be requested to give facilities to the Institute Staff to visit a factory in which such plant or process is being worked and to take such observations as may seem necessary in order to assess the scope and value of the process. Such preliminary data would, of course, be confidential and not for publication.
- (2) The Institute Staff will then report to the Experimental Sub-Committee who will consider the application in detail and make a recommendation to the Board as to whether the proposals should be entertained or not.
- (3) The capital cost of installing any such plant should be met by the firm desiring the test to be carried out, and in the event of the tests being unfavourable, the firm should be required to remove the plant and, if necessary, restore the original conditions.
- (4) In regard to all such work, the Institute will retain full liberty to publish in *The Tea Quarterly* or Institute Bulletins all data obtained whether favourable or otherwise.
- (5) In installing any such experimental plant, it would seem desirable to obtain a certificate from the firm or individual concerned that the installation as carried out meets their requirements in providing proper facilities for an adequate trial.

TEAS FOR THE LONDON MARKET.

During the year a resolution was received from the Planters' Association suggesting that invoices of St. Coombs Teas should be sold alternately in Colombo and London. The Board whilst sympathising with the proposal decided that as the present crop is small the proposal was not practicable, but would be further considered when there was a material increase in crop.

In October one half chest (40 lbs.) of each of the 3 principal grades was forwarded to the Ceylon Association in London with the request that reports should be obtained from the leading London Brokers and Buyers. The reports received indicate that the present system of manufacture is satisfactory and suitable for trade requirements of the London Market.

EMPIRE MARKETING BOARD.

The thanks of the Board are due to the Empire Marketing Board for granting the Institute's application for £1000-0-0 towards the purchase of experimental small-scale machinery.

The Institute's application for a grant of £2000-0-0 a year for three years for an investigation of the biological control of insect pests of tea and other crops in the Colony is still under consideration.

ST. COOMBS ESTATE.

Area—423 Acres, 2 Roods, 12 Perches, made up as follows:—

	A.	R.	P.
Tea in bearing	169	0	16
New clearings	65	1	07
Reserve for planting, patna, swamp, buildings, timber etc.	189	0	29
	423	2	12

The crop secured during the year was 112,208 lbs.

” 1929 was 103,257 ”

The average gross price obtained during the year was 1.14 cts. as against the Colombo market average of 95 cents.

A graph shewing the comparison between the St. Coombs prices and the Colombo market price for high-grown teas is attached.

Visiting Agent:—During the absence on leave of Mr. J. W. Ferguson, Mr. J. E. B. Baillie-Hamilton visited and reported on the Estate.

Two reports were made during the year.

DEPARTMENT OF AGRICULTURE.

The Board again desires to record its thanks to the Department of Agriculture for having seconded an Assistant for service with the Institute in connection with the Nettle Grub work in Uva.

The Board's appreciation is also due to the Director of Agriculture and Mr. Parsons for the assistance given in the laying out of the grounds at St. Coombs.

STAFF.

Senior Scientific Staff:—Dr. C. H. Gadd, (Mycologist), returned from leave and resumed duties on 3rd February.

Mr. F. R. Tubbs, M.Sc. (Lond), D.I.C., A.R.C.S., (Plant Physiologist) joined the Staff on the 3rd March.

Junior Scientific Staff:—Mr. C. A. Loos was appointed Assistant to the Mycologist as from the 1st April.

Mr. B. N. Sastri was appointed Research Assistant, Biochemical Division as from the 25th March.

TEA RESEARCH CONFERENCE.

It is intended to hold the Second Conference at St. Coombs on the 26th and 27th February.

DELEGATION FROM THE U. P. A. S. I.

In December a Delegation from the United Planters' Association of South India visited Ceylon and discussed a proposal to affiliate the South Indian Tea Research Institute with this Institute. The proposal is still under consideration.

PUBLICATIONS.

The number of copies of the publications of the Institute issued during the year averaged 1348 copies per issue.

To date the Institute has issued four Bulletins and three volumes of *The Tea Quarterly*.

Those who pay the Cess are entitled to receive copies of all publications if they register the names of their estates with the Secretary.

Others desiring all publications can register their names with the Secretary on payment of the following subscriptions annually :—

Rs. 15 for those residents in Ceylon or India.

£1-5-0 for those resident elsewhere.

Single numbers of the publications are available at Rs. 2.50 or 4 shillings each.

No spare copies of the following publications are available :—

Bulletins Nos. 2 and 3.

Tea Quarterly Vol. 1, Parts 1, 2, 3 and 4.

Do Vol. II, Parts 1 and 2.

To date 41 applications have been made for back numbers, should these applications increase, the Board would consider the advisability of reprinting these parts.

FINANCE.

The Audited Statement of Accounts is attached.

Cess :—To meet the extra capital outlay the Board considered it advisable to increase the Cess from 10 cts. per 100 lbs. of tea exported to 14 cts. for three years—1931, 1932, and 1933. This proposal was supported by all Associations concerned and comes into operation on 1st January, 1931. (*vide* "Ceylon Government Gazette" dated 14th November, 1930).

A. W. L. TURNER,

Secretary.

REPORT

ON

ST. COOMBS ESTATE

FOR THE YEAR 1930.

Superintendent:—Mr. John A. Rogers.

Acreage Statement:—

Tea in full bearing	...	165	0	16
Tea in partial bearing	...	4	0	00
New Clearings	...	65	1	07
Fuel Clearings	...	4	1	13
Reserve for planting, Waste land. Buildings		184	3	16
		423	2	12

Season 1930:—The season for crop in this district was not a very favourable one; during the second half of the year the weather was mostly unfavourable and cold. The total crop of this estate came to 112,208 lbs. of tea or 680 lbs an acre. Crop secured in 1929, 103,257 lbs.

Rainfall for the year was 88·77 inches compared with 76·12 the previous season, and was deficient, only 2·08 inches falling from 15th November to the end of the year.

Works were carried out during the year as per estimate.

Pruning 56 acres, this acreage had pruning mixture applied.

Manuring 165 acres, inclusive of pruning mixture mentioned above.

The pruning was done possibly rather lightly to suit the present state of the bushes. Next time, after 3 years' good cultivation, more might with advantage, be cut out, but in its present rather impoverished condition the tea would hardly stand it.

Expenditure:—The cost per lb. on Revenue Account comes to 73·44 cts. against 71·95 estimated; this is mainly on account of the shorter crop than estimated, items are very near the estimate.

The nett profit for the year, after deducting all capital expenditure will, it is anticipated, be approximately Rs. 7,500·00.

Manufacture:—The results of manufacture have been satisfactory, and the teas have netted approximately 1·08 for the year.

The samples sent to London have been well reported upon, and pronounced to be suitable for the London Market. From the view of running the estate on commercial lines, I would not advise selling in London as this mark has a good name and buyers in Colombo.

The clearings were supplied during the year. The basket plants have not been a success and will require re-supplying.

The stumps started well and have had a small application of manure. At the moment they are mostly alive but looking rather yellow, probably due to the very dry weather and cold nights in December.

The clearings have all been planted with *Tephrosia Vogelii* which is beginning to show and will, I hope, form a wind break and cover to the clearings which is what they want most, and should, in my opinion, have had from the start.

Dadaps were interplanted when supplying and though mostly alive are looking rather yellow.

Tea nurseries have improved since September.

To insure an adequate supply of plants, further nurseries are being prepared, seed from Cranley being booked for this purpose.

The Factory is well kept and the machinery is in good running order.

A new pump to the mist chamber has recently been installed to maintain an even pressure of water in the spray pipes.

1931:—The estimate for 1931 is for a crop of 125,000 lbs. With the weather now being experienced on top of the dry November and December and our dry months ahead, prospects are below normal.

It is proposed to open a further 30 acres in tea in 1931.

Water Supply:—A 4 in. main has been laid from the present source at the top of the estate to near the laboratory, where a general distributing tank is being constructed.

General:—The estate in general is an improving one and should do better when the present cultivation methods have had time to tell. Till the acreage in bearing has increased it is bound to be an expensive one to work, especially with so large a factory for the present crop.

(Sgd.) J. E. B. BAILLIE-HAMILTON.

15th January, 1931.

REPORT

OF

THE DIRECTOR,

TEA RESEARCH INSTITUTE OF CEYLON

FOR 1930.

Staff:—Mr. F. R. Tubbs, M.Sc., D.I.C., A.R.C.S., who had been appointed as Plant Physiologist in August, 1929, arrived in Ceylon at the beginning of March and was provided with temporary accommodation at St. Coombs pending the completion of the new laboratories.

Mr. B. N. Sastri, M.Sc., A.I.I.Sc., was appointed as Research Assistant in the Department of Biochemistry from 1st July, Mr. G. A. Loos as Assistant in the Department of Mycology from 1st April and Mr. M. Piyasena as Field Assistant from 15th December. The full staff of Senior Officers has now been appointed, but further additions will be made to the Junior Scientific Staff as finances permit.

Dr. C. H. Gadd, Mycologist, returned from leave on 3rd February, assistance in the advisory work of his section during his absence being given by Mr. M. Park of the Department of Agriculture.

Laboratories and Buildings:—The past year has marked another important stage in the development of the Tea Research Institute, since progress with the new buildings at St. Coombs was sufficiently advanced to permit of the transfer of the staff to the new laboratories during November and December. The Nuwara Eliya laboratory and the branch Entomological laboratory at Mahagalla were, in consequence, closed down and the work of all sections concentrated at St. Coombs. Naturally, a good deal remains to be done before the new laboratories will be in full working order, but the facilities, both in accommodation and equipment, now available have permitted of a considerable expansion in the experimental programme.

The whole building programme contemplated for 1930 has been carried out, details of which will be found in an earlier section of the report. Two Senior Staff Bungalows and four Junior Staff Bungalows now await construction, but the rate at which this work can be carried out must depend on financial considerations.

Visitors' Day:—The practice of setting aside the first Wednesday in each month as a Visitors' Day on which facilities are provided for visitors to inspect the Factory and Estate, has been maintained. This arrangement has proved popular and has been taken advantage of by a considerable number of planters, including many visitors from South India.

Library:—The accommodation available in Nuwara Eliya did not permit of any large additions to the Library during the year, nor was it possible to arrange for any systematic arrangement of the material available.

Plans have now been formulated for a considerable increase in the number of books and periodicals obtained, either by purchase or exchange, and a proper classification will be possible. Thanks are due to various donors for the gift of books and pamphlets.

Publications:—The circulation of *The Tea Quarterly* has continued to increase and a considerable demand has arisen for some of the earlier numbers which are now out of print. It is not, perhaps, realised that the Institute is both willing and anxious to include in *The Quarterly* articles by practical planters. Two such articles were published in the past year and aroused considerable interest.

WORK OF THE STAFF.

The correspondence passing through the Director's office during the year comprised 2,588 letters in and 1976 letters out. Addresses by the Director and other members of the Staff were given to various District Associations and a large number of visits paid to estates throughout the principal tea districts. Visits to District Associations afford a valuable opportunity to the Staff to acquaint themselves with local problems, and every effort will be made by the Director to arrange for addresses by officers of the Institute when desired.

Advisory Work:—It is satisfactory to repeat the observation made in last year's report that the number of applications made to the Institute for advice and assistance tends steadily to increase. A feature of the applications received during the past year is the interest now being shewn in regard to manufacturing problems. The successful results obtained in the St. Coombs factory have no doubt contributed to this but there is evident a greater realisation that, under such conditions as now prevail in the industry and with falling prices, more attention to *quality* of output is urgently necessary, particularly with mid and low country tea.

Inquiries regarding green manures and cover crops have also been numerous and indicate a slow but steady change of opinion from the policy of clean weeding to more rational methods of soil amelioration and conservation.

Mycology:—Speaking generally the year has been free from any marked incidence of fungus diseases. Root diseases, as in previous years, have been the most prevalent trouble, *Poria* being the most common complaint. It is perhaps necessary to stress yet again the highly infectious nature of this disease which has during the year also been found on *Tephrosia Vogelii*.

Red rust has been reported from several estates in the low-country, but it is probably only of serious importance when the attacked bush is already in poor condition from some other cause. Attention, however, may be directed to the views put forward by Dr. Gadd in his report as to the possible influence on the incidence of this disease of the lighter forms of pruning now practised at low elevations.

Dr. Gadd has also made a further study of wood rot and again confirmed his previous observation that decay may proceed below the callus of a healed wound if infection has occurred before such healing was complete.

Various specimens of diseased seedlings have been received during the year. In general, however, these have not given evidence of any primary fungus infection. The trouble in most cases would appear to be due to unfavourable condition of growth, *e.g.* unsuitable moisture condition in the soil, insufficient shading or unfavourable soil reaction etc.

Dr. Gadd has also recorded a root disease of *Acacia decurrens*, apparently caused by a species of *Aglaospora*. In no case, however, did the disease spread to adjacent tea.

In view of the divergence of opinion as to the importance to be attached to the fungus *Rhizoctonia bataticola* it is of interest to call attention to Dr. Gadd's observation that this organism is a common fungus in compost heaps where it readily break down the cellulose. This property alone would account for its common occurrence in the soil and decaying vegetable matter without any necessity for considering it a parasitic fungus.

Entomology:—Fewer complaints of insect pests have been received during the year under review and the larger number of enquiries referred to Mites, particularly Red Spider.

In the Passara district and other parts of Uva, serious loss has again occurred from attacks by Nettle Grub. Isolated reports of this pest have been reported from other districts in the last few years, but in none of these cases has any marked damage occurred. In Passara, however, the attacks have definitely increased in intensity and persisted over longer periods. Work on this pest was resumed in April 1930 with the co-operation of the Department of Agriculture, Mr. Austin being placed on deputation to the Institute for this investigation. Since that time a systematic study of the life-history of the different species of Nettle Grub has been begun and a search made for suitable parasites. At the same time, the utility of various sprays and dust for controlling the pest has been examined. Further details of the results obtained will be found in Mr. King's report and it will suffice to say here that spraying with soap solutions seems at present the most promising method of control. Infusions of *Tephrosia Vogeli* were also effective. In view of the serious damage caused by the pest it is proposed in the coming year to appoint further staff for this investigation. The thanks of the Institute are due to Messrs George Steuart & Co and Mr. G. Kent Deaker for facilities given in the course of this investigation.

Tortrix has on the whole caused less damage in 1930 than in the previous years. Considerable information has gradually been obtained regarding the conditions necessary for the successful breeding on a large scale of the Tortrix parasite, *Trichogramma erosicornis*, and many of the difficulties which have hitherto held back this work, have now found a solution.

In last year's report reference was made to an application made by the Institute to the Empire Marketing Board for a grant to defray the cost of a general survey of insect pests and their parasites in Ceylon. Unfortunately no definite reply has yet been received to this application. Further representations have, however, been made, stressing the importance of such work.

Plant Physiology:—Mr. Tubbs, the Institute's Plant Physiologist, only arrived in Ceylon in March and some time was necessarily occupied in familiarising himself with local conditions. Several important lines of work have since been taken up. Amongst these reference may be made to an attempt to raise clone stocks of tea. Any successful method of vegetative propagation would yield a supply of relatively uniform material for experimental purposes and much facilitate such work. Climatic conditions were particularly unfavourable to this investigation but it seems likely that successful results may be obtained, at any rate with low jât bushes.

Interesting results have also been obtained on the effect of transplanting and other factors on the growth of seedlings, details of which will be found in Mr. Tubbs' report.

Preliminary work in connection with pruning has also been done. A study of pruning in all its aspects will form one of the chief problems of this section, and both field and laboratory experiments on this subject will form an important part of next year's programme.

Agricultural Chemistry:—The analysis of the leaf samples from the Scrubs uniformity trial has been completed and the results prepared for publication.

With the co-operation of Mr. Boileau of Dunkeld Estate, a study has been made of the preparation of "artificial" farmyard manure from Maana grass by the Adco process. Experience in tropical countries of this process has not been consistently successful, the nitrogen content of the finished material often being unduly low. Considerable modifications were therefore made in the method of preparation with highly successful results. This experiment would suggest that where waste vegetable matter of a grassy nature, such as Maana grass, is available, there should be no difficulty in preparing a useful bulky manure.

Much of Mr. Eden's time was, however, occupied in preparatory work for the field experiments rendered possible by the move to St. Coombs. Towards the end of the year a series of manurial plots to investigate the influence of nitrogenous and potash manures was laid down. In addition to observations on yield and other conditions of growth, leaf from these plots will also be manufactured on the experimental side of the factory and some information of the effect of the treatment on quality may be obtained.

The Institute has constantly advocated a more extended use of cover crops. In order that further information may be available as to the suitability of different species, demonstration plots have been prepared on which some fifteen different varieties have been sown.

Biochemistry and Tea Manufacture:—As already mentioned, the Biochemical section during the past year has been repeatedly called upon for advice on various aspects of tea manufacture and these enquiries have raised many interesting points in connection with withering schemes, methods of rolling and humidifying problems. Owing to difficulties in regard to supervision no factory experiments could be commenced until Dr. Evans moved down to St. Coombs in October. The time before this was, therefore, utilised in collecting full data in regard to all stages of manufacture at St. Coombs. The figures obtained and the conclusions drawn from this analysis, which are given in detail in Dr. Evans' report, are of the highest interest and will well repay careful examination. Attention may in particular be called to the study of withering, which shews clearly, amongst other practical points, the disadvantage of working to a definite percentage wither instead of arriving at a constant moisture content in the withered leaf.

Side by side with the accumulation of factory data, the changes occurring during withering have been followed in the laboratory. The laboratory results are of equal interest, shewing clearly that withering does not consist merely in a loss of moisture, but that other important changes take place which are reflected in the amount of material which can be extracted from the leaf by water. Such a study is likely to have important practical applications and give valuable indications as to the optimum conditions of withering.

The first units of the small-scale experimental machinery, details of which have already been given in *The Tea Quarterly*, were received in December, but erection was not completed in time for any experimental work to be carried out by the end of the year. The cost of this plant was defrayed from a grant kindly given by the Empire Marketing Board.

Acknowledgments:—The acknowledgments of the Institute are again due to the Managers and Superintendents of many estates for their co-operation and help and for the hospitality extended to the Staff during their tours.

Mr. F. J. Whitehead has once more rendered invaluable assistance in connection with the design of the experimental plant and also in regard to the estate water supply and other engineering problems. We have also to acknowledge the loan of meteorological instruments by the Superintendent of the Colombo Observatory.

ROLAND V. NORRIS,
Director.

REPORT OF THE MYCOLOGIST.

Staff:—The Mycologist returned from leave on February 3rd. During his absence the advisory work of the division was carried out by Mr. M. Park of the Mycological Division of the Department of Agriculture to whom our thanks are tendered.

Mr. C. A. Loos joined the staff of this division on April 1st as Assistant to the Mycologist.

Agricultural Conference:—The Mycologist attended the Agricultural Conference at Peradeniya from October 20th to 22nd inclusive.

Advisory:—One hundred and forty seven consignments of diseased plants have been received for examination and report. Of these one hundred and twenty eight were tea, the remainder consisted of *Acacia*, *Albizia*, *Crotalaria* spp., *Cupressus*, *Dadap*, *Gliricidia*, *Grevillea*, and *Tephrosia*.

Visits have been made to 24 estates in the Ambawella, Dickoya, Dimbula, Hewaheta, Kandy, Matale, Nuwara Eliya, Panwila, Pelmadulla, Pussellawa, Ratnapura and Uda-Pussellawa districts.

TEA.

Root Diseases:—Root diseases continue to predominate. *Poria hypolateritia* continues to be the most prevalent root disease fungus, mainly because of the difficulty experienced in eliminating the fungus from the soil. The removal of dead bushes alone is insufficient; infected bushes on the perimeter of the attacked area must also be removed before they show any above-ground symptoms. This necessitates the examination of the root systems at the time dead bushes are dug out. It is false economy to wait until the bushes are moribund, as by that time the fungus has passed on to the roots of adjacent bushes. It appears necessary also to issue a further warning concerning the highly infectious nature of this disease. Care must be exercised in the collection and destruction of all diseased roots.

The incidence of brown root and *Ustilina* diseases continues to decrease. Brown root disease is becoming almost a rarity on tea, due mainly to the extensive stumping programmes which have been carried out in past years. Both of these diseases are relatively easy to eradicate from attacked areas if care is taken to ascertain and destroy the roots on which the fungus originates.

Opportunities for the further study of the fungus *Armillaria mellea*, which causes a root disease of tea, was afforded by the discovery of its presence on an estate in the Nuwara Eliya district. A full account of the disease was published in *The Tea Quarterly*, Vol. 3, Part 4. It is essential in the treatment of this disease, that the old stump or root from which the infection occurs be sought out and destroyed. The infecting jungle root is very often deep seated; in one instance the root was found below the level of an old field drain. So far, the removal of dead bushes and the destruction of ascertained sources of infection have afforded complete control of the disease.

The recognition that the so-called Diplodia root disease is the consequence of a deficiency of internal food reserves at the time of pruning, and not of the attacks of pathogenic organisms, has resulted in a great reduction of the loss attributable to this cause in Ceylon. The old type of clean pruning is gradually being abandoned, at lower elevations, for a lighter type of pruning which leaves a large amount of green leaf on the bush after it is pruned. This allows the bush to continue to manufacture its necessary organic food supply and does not leave it dependent upon an internal reserve.

Stem Diseases:—*Macrophoma theicola*, the cause of a true branch canker of tea commonly attacks tea stems about half an inch in diameter and kills small areas of the bark, an inch or so in length. With the subsequent growth of the stem these areas remain depressed below the general level and become surrounded by a swollen callus. In this way typical cankers are formed, and the fructifications of the fungus are commonly to be found in the dead bark which persists within the wound. The same fungus has been recorded on older stems.

Similar cankers have been found on the larger branches of young seed bearers. In some cases, the stems are completely girdled, with the result that the entire branch above the canker dies. In others, one side of the stem only is attacked for a length of two or three feet, the boundary of the canker being marked by a distinct raised line of callus. Associated with these cankers was the fungus *Desmotascus neglectus*, which Petch regards as the perfect stage of *Macrophoma theicola*. The spore measurements obtained from these specimens were smaller than those given by Petch in his description. The Mycological Herbarium at Peradeniya, however, contains specimens of *D. neglectus*, marked by Petch "Small spored form," the spore measurements of which agree with those of the recently collected specimens.

Later, the same fungus was found in the bark of cankers and of die-back branches of tea in plucking. In this instance also, the fungus was the small spored form. In neither case was a pycnidium of *Macrophoma* found, but the similarity of the cankers lends support to the conclusion that *D. neglectus* and *M. theicola* are but two forms of the same fungus.

Red rust (*Cephaleuros parasiticus*) has been reported from a number of estates in the low-country during the year. In many cases, although the alga was prevalent on the branches, it appeared to do very little damage other than to result in the production of a number of variegated leaves which are symptomatic of the disease. But for these, an observer would not suspect that anything was amiss with the bushes, unless he made a careful examination of the branches. The bushes appeared vigorous and flushed

well. It is only when the bushes are weakened as a result of other causes, such as poor drainage etc., that the parasite becomes of serious importance. It is probable that, with the lighter pruning now practised at low elevations, this alga will become more prevalent, as when the bushes are clean pruned regularly at intervals of eighteen months or two years, many infected branches are removed at an early stage of infection. With a lighter prune the bushes are not so thoroughly cleaned out and more infected branches are left. For this reason a periodic clean prune may be necessary at intervals where cutting across is becoming the normal practice.

Tests carried out with the fungi obtained from the rotting cavities of tea branches (wood rot) indicate that the majority of the fungi isolated are not able to cause decay in tea wood. This result is not surprising as it is to be expected that numerous fungi find in the wood, partially decayed by other fungi, a medium in which they can thrive. These fungi would be isolated more readily and with greater frequency than those fungi which initiate the decay.

One observation emanating from these investigations is perhaps worthy of record. One fungus, isolated from partially decayed wood below a completely healed wound, proved to be a very active destroyer of tea wood. This observation affords direct evidence of what has been stated previously, viz., that the healing of wounds is not a cure for a wood rot which has started, and that decay may proceed below the callus of a healed wound if infection occurs before the wound is completely healed.

The die-back of branches after pruning is more frequently the result of physiological conditions than of the attacks by specific parasitic organisms. Where this occurs the best remedy is a secondary prune. The 'die-backs' should be pruned out as close to the nearest new shoot as is possible, some time before the fields are tipped. No 'pegs' should be left. This, of course, is work for skilled pruners.

Leaf Diseases:—Leaf diseases have not been unduly prominent during the year. No new disease has been recorded nor has any severe attack of the known diseases been reported. The disease caused by *Cercospora theae* has not been prominent this year in the fields in which it commonly occurs, owing mainly to the lightness of the south-west monsoon.

Seedlings:—Attention has been given to the investigation of the diseases of seedlings, but except in very exceptional cases the cause cannot be definitely ascribed to the activities of pathogenic organisms. The diseases appear to be more intimately connected with environmental conditions, particularly water supply, shade and soil reaction. An excessive water supply which results in water-logging of the soil, such as may occur with heavy rains where the drainage of the nursery is inefficient, leads to a rotting of the finer roots and frequently of the tap-root. The result of the damage is not immediately reflected by above-ground symptoms. Growth is retarded or stopped, but it is not until some time later that deaths occur, by which time all evidence of the water-logged condition of the soil has disappeared. This type of disease is commonly known as "Bitten off," owing to the root system having more or less completely disappeared as though it had been eaten by insects. The end of the tap-root which remains, however, is in a decayed condition and has not the clean cut surface such as is usually left after an insect injury. A similar condition results when seedlings are grown in soil of unsuitable reaction. This

commonly occurs where the sites of old coolie gardens are used as tea nurseries. In such cases the soil is not sufficiently acid for healthy growth. Where such sites have to be used a previous application of sulphur would probably be beneficial.

When shading is inefficient the seedlings may be severely injured at ground level. This type of disease is known as "Collar rot." In other cases the lack of shade results in a leaf scorch; subsequently, the injured leaves are commonly attacked by parasitic and other fungi. In the majority of cases examined these fungi followed scorch and were not the primary cause of the trouble.

A third type of disease has come under observation during the year. It is characterised by a dwarfing of the leaves and a shortening of the internodes. The root system, particularly the feeding roots, is poorly developed but as a rule there is no definite symptom of "Bitten off." No fungus has been found to be constantly associated with the disease and frequently no evidence of invasion by any pathogenic organism could be ascertained. The disease has occurred on soils which dry out rapidly and tend to form a pan on the surface. In such circumstances artificial top watering is relatively inefficient. There is thus *prima facie* evidence that the cause of this trouble also is connected with water supply.

Tea Seed:—The quality of the seed crop this year in certain districts has been below normal, as shown by the larger numbers of light seed at the time of collection. In one instance 36 per cent. of the seed collected were not normally developed. Some seed were quite empty; the shell had developed normally but there was no trace of any germ or cotyledons (the kernel) within. In others, the formation of the germ and cotyledons had proceeded along normal lines but as much as one half of the volume of the cavity enclosed by the shell remained empty. There was no trace of invasion by fungi or insects at the time the seeds were shed. The cause of this state is obscure but it would appear to be more the result of physiological conditions than of attack by pathogenic organisms.

In another case the freshly gathered seeds when shelled had the appearance of old seed, as regards both colour and texture. The moisture content of the cotyledons was found to be 16·2 per cent. as against 37·5 per cent. of other seed stored for 3 months in a sealed tin. These figures indicate that the seed had dried out before being shed. This conclusion is supported by the fact that the shelled seed readily absorbed water on soaking and assumed the normal appearance of fresh seed. No explanation of this occurrence can be offered at present.

Witches Broom:—In the Annual Report for 1926 the possibility was suggested that the term 'Witches Broom' of tea is applied, in Ceylon, to a number of diseases having similiar symptoms, but which are the result of different obscure causes. This view is supported by a number of observations made during the year. Recent observations indicate that at least one form of the disease spreads slowly from bush to bush and that a possible agent of dissemination is the pruning knife. So far, it has not been possible to identify, from morphological characters alone, this "spreading" form from others which show no tendency to spread, though the latter have been under observation for some years. These observations again bring to the front the possibility that the cause of one type of this disease is a form of virus. Previous experiments in this direction were unsuccessful and inconclusive.

When this disease occurs it is advisable to prune the affected bushes after all the healthy bushes in the field have been pruned. This would minimise any risk of transmitting the disease to healthy bushes by means of the pruning knife. After pruning diseased bushes, the knives should be sterilised in boiling water.

An obscure disease has been reported from Nyasaland which bears close resemblance to that form of "Witches Broom" which in an earlier report (1926) the writer termed Chlorosis. Chlorosis is not common in Ceylon but it is interesting to note that the suggestion has been put forward in Nyasaland that there the disease is possibly also the result of an infectious virus.

GREEN MANURES.

A root disease of *Acacia decurrens* has been recorded from two estates in different districts. The first symptom observed is usually the death of the tree; sometimes death appears to occur suddenly, the whole tree dying while in full leaf; less frequently one or two branches on one side of the tree die first. The cortex of the dead roots is black and this discoloration extends into the wood. The trouble appears to be caused by a species of *Aglaospora*, quite distinct from *A. aculeata* which causes a stem disease of tea. This, of all the fungi isolated from diseased roots, is the only one found to cause infection when inoculated on the roots of healthy young *Acacia* plants. This fungus has been found to be associated with the diseased roots of all the diseased *Acacias* yet examined so there is *prima facie* evidence that it is causal fungus. In no case did the disease spread from the *Acacias* to the adjacent tea bushes.

Eelworm and *Poria hypolateritia* have been found to cause disease of the roots of *Tephrosia Vogellii*.

COMPOST HEAP.

Investigations into the fungus flora of a compost heap have been undertaken at the request of the Agricultural Chemist. The changes which take place in a heap during the course of its decomposition are mainly the results of the activities of micro-organisms of which the fungi constitute an important fraction; from which, it would follow, that the nature of the changes and the rate at which chemical changes take place in the heap will be dependent on the constitution of the flora as well as on other factors. If the results of the chemical analyses made in Ceylon are to be correlated with those made elsewhere under different climatic conditions, some assurance is necessary that the active floras in the different cases are similar before the true value of other factors can be ascribed.

One observation of considerable interest from the pathological viewpoint is that *Rhizoctonia bataticola* (Haig's group B) proved to be a common fungus in the heap and that it readily attacks and breaks down cellulose. This fact would offer an explanation of its prevalence in Ceylon soils and of its frequent occurrence on dead roots of numerous plants without assuming that it is in any way parasitic. In all probability its principal rôle is to break down dead vegetable matter and to assist in the formation of humus. In this respect its presence must be regarded as beneficial.

C. H. GADD,
Mycologist.

REPORT OF THE ENTOMOLOGIST.

Correspondence:—There was a drop in the number of enquiries received during the year, compared with previous years. 70 letters were acknowledged, of which 62 related to pests of tea, and 8 to those of green manures.

Mites:—More than a third of the letters referred to Mites, Red Spider being the commonest, most of them coming during the dry weather of July and August.

The standard remedy against Mites the world over is the application of Sulphur in some form. Dusting with Sulphur powder, spraying with a Sulphur compound, or fumigating with a suitable compound, are the usual methods of dealing with Mites. For small areas, spraying would be more effective than dusting, but the latter is usually easier over a large area. It is best to apply the Sulphur immediately after plucking, and to leave as long an interval as possible before the next plucking to avoid any possible risk of tainting.

Nettle Grub:—The special investigation into these pests which began in 1929, was restarted in April 1930, and was in charge of Mr. G. D. Austin, who was seconded for the special work by the Department of Agriculture.

The preliminary phase of the enquiry has been devoted to the study of the life-histories of the various species concerned. These are:—

Narosa conspersa

Natada nararia Mo

Thosea cervina Mo

Do *recta* Hmps

Do *cana* Wlk

Parusa lepidu

Spatulifimbria castaneiceps

In general the life cycle is some two to three months.

The larval period, during which the tea suffers damage, is about two months in the case of all except the first two, which are somewhat shorter. The work on these insects in the laboratory has been rendered difficult by the failure of some species to lay fertilised eggs, and further difficulties were encountered by the invasion of Wilt, which killed off many of the caterpillars before the cycle was completed.

The parasites *Apanteles*, *Rhogus* and *Fornicia ceylonica* were bred out during the year and also an unnamed *Tachinid*. *Fornicia*, formerly supposed to be specific on *Natada*, was bred also from *Thosea cervina* and *T. recta*. An endeavour was made to breed the parasites on caterpillars other than those in which they were found, but without success hitherto. It would not appear probable that the artificial breeding of indigenous parasites would be successful in this case, and if any good results are to be obtained by means of parasitic control, the parasites to be employed

will have to be found outside the island, possibly in Malaya or the Pacific Islands. The following is a list of parasites attacking Nettle Grubs, but it makes no pretence to being complete:—

PARASITE	HOST	LOCALITY
<i>Apanteles belippae</i>	<i>Belippa</i> spp.	Java
Do <i>caneae</i>	<i>Cuneia bilinea</i>	"
Do <i>parasae</i>	<i>Parasa lepida</i>	" & Ceylon
Do sp.	<i>Thosea cervina</i> }	Ceylon
	" <i>recta</i> }	
<i>Chaetexorista javana</i>	<i>Setora nitens</i>	Java
<i>Chlorocryptus</i> sp.	"	"
<i>Compsilura concinnata</i>	<i>Thosea cervina</i> }	"
	" <i>sinensis</i> }	
<i>Euplectrus</i> sp.	<i>Setora nitens</i>	"
<i>Fornicia africana</i>	A Limacodid on coffee	S. Rhodesia
" <i>ceylonica</i>	<i>Natada nararia</i>	Ceylon
	<i>Thosea cervina</i> }	
	" <i>recta</i> }	Celebes
" <i>thoseae</i>	<i>Thosea porthetes</i>	
<i>Rhogas</i> sp.	<i>Narosa conspersa</i>	Ceylon
"	<i>Natada nararia</i>	"
"	<i>Parasa lepida</i>	"
<i>Rhogas</i>	<i>Setora nitens</i>	Java
"	<i>Thosea cervina</i>	Ceylon
"	" <i>recta</i>	"
<i>Spinaria armator</i>	<i>Setora nitens</i>	Java

As Nettle Grubs at certain seasons succumb to Wilt very readily some preliminary experiments were tried to find out if this might be disseminated artificially. Some wilted caterpillars were macerated in water, and the fluid sprayed on to fresh insects, or on to bushes on which they were placed afterwards. The results were apparently encouraging, but there is a difficulty in obtaining caterpillars for the purpose which are known to be free from wilt. Very little is known about the disease, and nothing about the causative organism itself, so that a great deal more knowledge is required until it can be handled with any certainty.

A variety of insecticides were tried out against the grubs. Several different preparations of pyrethrum were used, some as a spray, and some as a dust. Other alkaloids tested were nicotine, derris and tephrosin. All these, used in sprays, gave fairly satisfactory results except nicotine, but the dusts were of no value. Sulphur, sodium silicofluoride, calcium cyanide and soaps of different kinds were also tried. Taking them all round, plain soft soap appears to be as satisfactory as any, and the cheapest, although the addition of an infusion of the leaves of *Tephrosia Vogelii* would probably increase the toxicity. Spraying suffers from the handicap of so much labour being required over big areas, from difficulty in many places of water transport, and from the fact that the spray may get washed off soon after by heavy rain. Nevertheless, it is, at present, the only positive means of dealing with the pest, besides handpicking.

Tortrix:—This pest did not appear to have been particularly severe in 1930, except in a few very restricted areas.

Considerable advance was made in the technique of breeding grain moths for parasite work. The moth used throughout was *Ephestia cautella*. It was first recovered from maize, and maize was used as food for a time, but the rate of reproduction was unsatisfactory. Maize meal was then tried, and found considerably better, and was used most of the year. However, in a large number of experiments, the recovery of moths from eggs used for multiplication was between 2 and 6%. A considerable wastage in effectives seems to be inevitable, but an endeavour was made to find a food giving better yield. White wheat flour, gram meal, soy bean meal, linseed meal, paddy, coconut poonac, groundnut meal, Sussex Groats and a mixture of 4 parts maize meal with 1 part linseed meal were tried out on a small scale. The quickest return is given by maize meal, the cycle being five weeks, all the others being about eight weeks, at 75°F, but the best yield was given by the gram meal, the recovery from the others being comparatively poor.

The breeding was carried out in cages of about one cubic foot capacity, with about three inches of meal at the bottom. Collection of moths was made by means of tubes, a slow and laborious method, but it is hoped to substitute electric suction and a special type of rearing cage has been designed in accordance with this. Glass jars, with bolting silk over the mouths, were used as egg deposition cages.

The yield of eggs early in the year was about 150 eggs per female, but this had declined to 100 at the end. In the food trials, moths bred from gram meal gave the best yield, at 130 eggs per female, followed closely by the linseed meal moths, with 124; the remaining gave 100 or less.

Trichogramma Erosicornis:—Owing to the slow rate of reproduction of the moths, mentioned in the previous section, it was decided not to try and breed as many parasites as possible. It was noticed that the reproductive rate of the parasites was very variable, and it was therefore thought better to try and breed up better strains by bulk selections. Promising strains were selected as they arose, and used for further propagation, the criterion being the number of parasitised eggs per female. At first, the arbitrary number of 6 was taken, those parasitising less than this number were discarded. This number subsequently increased to 10, 15 and 20. The original selections were taken through twenty-four generations. Generally speaking, improvements were not maintained, but the number parasitised showed an irregular rise and fall. Eggs given for reproduction were always well in excess of the previous reproductive number. Thus, those parasites arising from parents parasitising 15 eggs per female were given 25 or 30 eggs per female. Towards the end of the year, some larger bulks were tried to see how they fared on a larger scale. In this case the number of eggs per female were reduced. Thus, progeny from parents with a capability of 15 were given only 10 eggs per female, and this was again reduced to 8, 7, and 5. The result showed that however reasonably small the numbers of eggs per female were no more than 80% parasitism could be expected.

Different results were obtained when different eggs were used. The scheme was to submit these eggs to parasites derived from *Ephestia* eggs and to hand over the progeny to *Ephestia* eggs again. The general result noted was that the rate of parasitism of *Ephestia* eggs depended on the size of the parasite, which itself varied with the size of the egg employed. The eggs of *Sitotroga*, another grain moth, which are smaller than those of *Ephestia*, often failed to yield parasites; when they did, the rate of parasitism of *Ephestia* eggs was about 1 egg per female. Parasites from *Tortrix* eggs parasitised about 30 *Ephestia* eggs per female. Parasites from eggs of various moths larger than those of *Tortrix* were able to parasitise 40-60 *Ephestia* eggs per female. The difference in size of these variously bred parasites appear to be mainly centred in the abdomen. For this reason, an endeavour was made to get a smaller species of *Trichogramma* than that found in Ceylon. Two shipments of *T. nana* were received from Malaya; in the first all the parasites were dead owing to delay in transit. There were a few survivors from the second, but they were in a very feeble condition, and after one generation, they died out. Later, a consignment of *T. minutum* was received from California, but these were also dead on arrival. When eggs are again plentiful, it is hoped to get a supply from Europe. *T. minutum* is known to breed satisfactorily in the eggs of *Sitotroga*, and therefore should be at least equally satisfactory for *Ephestia*, while *T. evanescens*, found in Europe, will average about 50 eggs per female in *Ephestia* ova.

Breeding was interrupted in December by the move to St. Coombs. A special plant for this purpose has been designed, the capabilities of which when running to full capacity, will be about three to four million parasites per day. The first objective will be one million per day.

Other pests of tea which came under notice were:—

1. **Leaf Eaters:**—Red Slug (*Heterusia cingula* Mo); Tea leaf Roller (*Gracilaria theivora*, Wlsm); Bagworms *Psyche* spp.)
2. **Stem Borers:**—Red Borer (*Zeuzera coffeae* Nietn); Shot-Hole Borer (*Xyleborus fornicatus*, Eichh.)
3. **Plant Sucking Bugs:**—Tea mosquito Bug (*Helopeltis antonii*, Sign.)

PESTS OF GREEN MANURES.

1. **Albizzia:**—Albizzia caterpillar (*Terias silhetana*, Wall)
2. **Boga:**—Mealy Bugs.
4. **Dadap:**—Weevils (*Astycus immunis*, Wlk.)
4. **Dadap:**—Weevils (*Astycus immunis*, Wlk.)

C. B. REDMAN KING,
Entomologist.

REPORT OF THE PLANT PHYSIOLOGIST.

The Plant Physiologist arrived in Ceylon on 3rd March, 1930. In the absence of accommodation in Nuwara Eliya, he proceeded to St. Coombs after a short period at "Lindfield." The Biochemist's factory office was occupied till October, when the permanent physiological laboratory was taken over. During September, October and November he was in charge of the clearing and planting of the laboratory and bungalow sites at St. Coombs.

Correspondence and Visits:—Eighty-eight letters were received and 101 despatched. Estates in Dimbula, Madulkelle, Uda-Pussellawa and Uva were visited.

Pruning:—Swarbrick ⁽¹⁾ has shown that apple and rhododendron, among other trees, reacted to pruning by the production from the starch in the neighbourhood of the wound of a viscous substance which blocks the vessels and prevents the entrance of disease organisms. This layer of gummy material was also found to prevent the suction of fluids and dyes through the vessels of the stem. In the case of tea, it was found that although the movement of dyes was prevented in wounds ten days old, no such band of wound gum could be demonstrated. In this case, it is possible that dye movement is impeded by the formation of air locks in the vessels. It was noticed that a small number of what appear to be tyloses are formed in the vessels just below the pruning cut. Analyses performed by the Biochemist showed that the tannin content of the branches is very low and that no regional change occurred in the neighbourhood of the pruning cut that was detectable by macrochemical means.

Several preliminary experiments upon pruning have been undertaken, preparatory to field work in 1931.

Clone Stocks:—Attempts to raise clone stocks of tea have been made. An explanation of their value may be made here. Every tea seed-bearer being of very mixed ancestry, even while conforming to certain "jât" characteristics, it follows that the seedlings resulting from such trees will show considerable variation. The selection of a "pure line" of seed-bearers is impracticable, although selection would diminish the variability. To obtain more uniform material for experimental purposes, vegetative propagation must be resorted to.

Disappointing results were obtained by use of cuttings from medium jât bushes, but given better climatic conditions than were experienced in 1930 the method should be successful with low jâts. Etiolation of the bases of young shoots is now being tested, as this treatment has been of considerable use in increasing the ease of propagation of fruit tree stocks in England. It has been found that medium jât bushes remain inactive if covered with a layer of earth after pruning back. The young shoots are therefore being allowed to grow to a few inches in length and are then earthed up. They will then be used as cuttings.

In this connection it may be noted that Kingsford and Kelway Bamber ⁽²⁾ report that tea in Formosa is nearly always propagated by layering in order to maintain the type of tea from which their oolongs are produced.

Effect of Transplanting on the Growth of Seedlings:—28 months old seedlings were planted without leaves or rootlets being removed. Thirteen fortnightly samples were taken to examine their establishment. Owing to a spell of dry weather immediately after planting, it was found that dying back of the young shoots and fine roots occurred, the leaves also falling.

The immediate result of planting was the abscission of a large number of leaves, the dry weight of leaves per plant falling from 402.1 grammes at the commencement of the experiment to 24.0 grammes a month later. During the following two and a half months the abscission of the remainder of the original leaves continued. Three months from planting new leaf growth commenced, new root growth having begun a fortnight earlier. After transplanting, the fine rootlets underwent morbid changes but abscission was found to be very gradual, old rootlets still occurring in small numbers six months afterwards. The main bulk of the old rootlets were lost during the fifth month after planting.

TABLE I.

Ratio: dry weight of fine roots
dry weight of taproots.

SAMPLE :—	1	2	3	4	5	6	7	8	9	10	11	12
	·048	·049	·052	·065	·056	·063	·064	·039	·031	·035	·038	·061

It will be noted from table II that new leaf growth follows after the production of new rootlets. The occurrence of cases in which new leaves had been produced in the absence of new root growth suggests that they are produced independently of each other.

TABLE II.

Number of plants in a sample of 60 showing new growth.

SAMPLE :—	1	2	3	4	5	6	7	8	9	10	11	12	13
Leaves	0	0	0	0	0	16	24	30	32	37	42	36	33
Roots	0	0	0	0	23	27	43	41	41	37	42	46	35

After four months the water content of leaves, fine roots and taproots had recovered to the initial value. It appears that under the climatic conditions experienced, i.e., a prolonged spell of dry weather after planting, the fine roots do not function, but die away. It is possible that salts are translocated from the dying rootlets into the taproot and are there used in the production of young rootlets. This will be tested by analytical work.

Growth of Seedlings:—An experiment involving the examination of some of the factors affecting the growth of seedlings in the field was commenced in May and will extend over eleven months. Ordinary estate practice was departed from and after the removal of floaters the seed was planted in its permanent quarters after being treated in one of two ways :—

- (a) Seeds weighed individually and planted.
- (b) Seeds weighed individually and the shell removed, the cotyledons then being weighed and planted.

From data collected it was possible to make an estimate of the dry weight of the food reserve (i.e., the cotyledons) with which each embryo started growth.

Samples were taken at monthly intervals thereafter. The results to date indicate that the range of variation in the sizes of individual seeds occurring in commercial supplies is not sufficiently large to produce any appreciable effects upon the size of the resulting plants. That seed size does have an effect is demonstrated by table III in which the results are given of a comparison between seedlings from large seeds and those from very small seeds (such as are normally thrown out).

TABLE III.

	Large Seed	Small Seed
Number of seeds in two ounces	23	126
% of plants resulting after 191 days	91.4%	66%
Mean dry wt. of plants after 191 days	1.033 grms.	0.232 grms.

The shell of the seed is cracked either by the swelling of the cotyledons when water is absorbed or by the combined action of the growth of the root and the swelling. The percentage of shells found to have been cracked were 25% after one month, 72% after two months and 100% after three.

The removal of the seed shell produces a pronounced increase in the size of the plant at first, but this effect rapidly decreases.

TABLE IV.

Dry weight of plant less cotyledons at successive monthly samples.

SAMPLE	1	2	3	4	5	6	7
Not Shelled	0.0008	0.0430	0.1386	0.2294	0.4963	0.9006	1.1973 grs.
Shelled	0.0144	0.0939	0.2731	0.6108	0.7242	0.8654	1.5736 grs.

This effect upon the size of the seedling is reflected in the change in weight undergone by the cotyledons, as is shown in the following table:—

TABLE V.

Change in weight of the cotyledons

SAMPLE	1	2	3	4	5
	+0.0190	—0.0414	—0.1838	—0.2811	—0.5568 grs.
	—0.0400	—0.0838	—0.3332	—0.5595	grs.

Note: Figures are not given after abscission of the cotyledons has commenced.

It is probable that this loss is made up of two phases—firstly the transmission of food materials to the seedling during the first three months and secondly a rotting of the cotyledons independently of the seedling, during the period between the formation of an abscission layer and the actual physical abscission of the cotyledons. The figure of three months for the period during which the seedling was absorbing food from the cotyledons is tentatively suggested from the observation that growth was not exponential in character until after this period had elapsed. The loss in dry weight is accompanied by a rapid increase in the water content of the cotyledons. The percentage of cotyledons cut off by the plant increases rapidly after the fourth month as is shown in table VI.

TABLE VI.

SAMPLE	4	5	6	7
Not shelled	0·0%	0·0%	26·9%	22·7%
Shelled	0·0%	17·9%	60·0%	69·1%

It is found that the dry weight of the seed-shell does not change appreciably in seven months, showing the absence of decomposition.

The ratio of **shoots plus leaves: roots** increases rapidly at first and then more and more slowly.

It appears that if favourable climatic conditions occur just after planting of the seed, shelling will have a good effect, the more rapid growth enabling the plant to take advantage of the conditions, but the treatment has not yet been shown to be economic.

An examination of a seedling trouble appearing in the nurseries of St. Coombs, in conjunction with Agricultural Chemist, lead to the conclusion that it was due to an insufficient supply of water. It has been noted that after moister conditions prevailed a large number of the seedlings recovered, though they still show some effects.

Plucking:—The flush regeneration time (i.e. the time taken to produce pluckable flush from the buds remaining on the bases of the shoots of a flush) has been found to be in the neighbourhood of seventy days. As this will probably vary with climatic conditions and time from pruning, it is intended to examine this further.

Summary:—The results of experiments upon pruning, transplanting and the growth of seedlings are reported.

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F. R. TUBBS,
Plant Physiologist.

REPORT OF THE AGRICULTURAL CHEMIST.

Advisory:—Letters received : 110. Letters despatched : 127.

LABORATORY.

During the year, owing to the impending removal to permanent quarters and the attention this has entailed, no new investigation has been commenced. The analyses of the leaf from the Scrubs uniformity trial have been completed and the results will be reported in full elsewhere at a later date. The completed figures continue to support the relationships outlined in the 1929 report, viz., that the ash content shows significant relationship with climatic conditions and that in this locality the S. W. monsoon period is, in its initial stages, unsuitable for the manurial utilisation of nutrients and consequently unsuitable for manuring operations, particularly with soluble nitrogenous manures.

Artificial Bulk Manure.—Towards the end of 1929 an experiment was started which aimed at following the decomposition of waste vegetable material—in this case Maana grass—into an artificial farmyard manure by the 'Adco' process. This process provides a manure rich in humus and relatively rich in nitrogen. Experience in Ceylon and certain other tropical countries has shown that in some cases the end product, whilst having the physical appearance of a well-rotted bulk organic manure, is very low in nitrogen and hence of only inferior value. In all cases brought under notice, the time which elapsed between the commencement of the process and the utilisation of the finished product exceeded by several months the time which is requisite for the fermentation process to be completed. The present experiment was accordingly planned so as to follow up both the process of manufacture and that of storage, in order to determine at what point loss was heaviest. Sampling was carried out at monthly intervals over a period of eight months. At each sampling, samples from six positions in the pit were obtained; from these a detailed knowledge of the behaviour of the material was acquired.

In temperate countries it is customary to manufacture artificial farmyard manure in heaps. The strong tropical sun and the long periods of dry weather experienced in certain parts of the country make this practice inadvisable as it is essential to the process that the material be kept moist. Consequently, in the tropics pits have largely been used. Under such circumstances there is a grave danger of water-logging owing to the close nature of the sub-soil, a condition which militates against the success of the process.

In our experiment we have compromised by digging a clearing in the side of a bank so that three sides are enclosed by the earth and the fourth maintained by galvanised iron sheets. This method both preserves moisture and prevents water-logging, and, from the results so far collected, is to be recommended. At the end of the experiment, after the dry period of the latter part of the N. E. monsoon, the average moisture content of the heap never fell below 55 per cent calculated on the fresh weight.

The appearance of the heap showed that the breaking down of the material was rapid and a well-rotted manure was obtained in three months. This was also borne out by the chemical determination of those readily available energy providing foodstuffs on which the micro-organisms which bring about the fermentation depend. In three months some fifty per cent

of the total pentosans in the heap had been dissipated. The balance was roughly equivalent to the pentosan content of the cellulose at the beginning of the trial which Rege regards as being of a less available nature than that obtained from other sources. The rapidity of this decomposition has raised an interesting point. Norman in an investigation, subsequent to that of Rege, disagrees with the latter concerning the availability of the energy supplying material locked up in the cellulose. Both agree that the speed of the rotting process depends upon the ratio of available foodstuffs, measured as "available" pentosans, to an inhibitive material which they agree is lignin. Both have accordingly classified the several raw materials they used as (1) quickly rotting, (2) slowly rotting and (3) unsuitable, and have defined the limits of the pentosan-lignin ratio relevant to each class. Since they do not agree in their definition of "available" pentosans, their ratios are not concordant. The Maana grass used in our experiment was analysed according to the schemes of both the above workers with the following results :—

			Actual Ratio	Ratio required for rapid rotting	
Rege	...	...	0.46	...	1
Norman	...	...	2.68	...	3.4

It thus appears that the chemical criterion of a good rotting material in neither case fits our observations, but that Norman's formula is a better indication of the possibilities. This aspect is receiving further attention. So far the indications are that a suitable bulk manure useful for nurseries can be easily prepared from the waste vegetable matter of a grassy nature mainly composed of Maana grass.

Soil work, except for advisory purposes, has been in abeyance, waiting for the enhanced facilities offered by the new laboratories. The work of the division has also included a number of routine analyses of manures for use on field experiments.

FIELD EXPERIMENTS.

The removal of the Institute to St. Coombs has enlarged the scope of field work that can be undertaken. The most suitable area for experiments on mature tea came into pruning in November before the removal of the Institute as a whole to St. Coombs. In order therefore to make the best use of facilities, work preliminary to the establishment of field experiments on this area has been given a prior claim on the writer's time. This work has fallen under two heads, the first of which was the completion of the investigation on the fundamentals of design and arrangement of tea experiments which was necessary before the exact form of a detailed agricultural experiment was decided upon, and secondly, the setting up of new experiments themselves.

Experimental Technique:—In the 1929 report the completion of the field work on the uniformity trial at Nuwara Eliya was recorded. The examination of the whole data has been completed in the period now under review and a detailed account submitted for publication. Here, the main results only are summarised :—

(1) The necessity for expressing all yields in terms of dry matter owing to the vagaries of the climate has been confirmed. Further, the errors associated with this method of procedure have been examined and have been

shown to contribute only a negligible amount to the errors of working the experiment as a whole. In point of fact they amount to only 1·2% of the total error encountered.

(2) The difficulties inherent in the existence of marked heterogeneity in field plots have been shown to be more serious than with temperate crops and soils, and less easily overcome. The maximum useful diminution of error was found to occur with plots of 1/18 acre.

The consistency of behaviour of plots from plucking to plucking is satisfactory, despite the fact that there is some variability in the standard of plucking attained by different pluckers from time to time.

(4) The above consistency suggests the possibility of recording yields on intermittent occasions instead of every plucking round. Such a procedure would go far to bring substation or other co-operative experiments within the bounds of practical politics. On the basis of every third plucking it has been shown that the correlation between the behaviour of treatments under the two methods, and between the errors associated with them is significantly high. Provided that the plucking is good on the intermittent occasions the method appears to be of distinct promise.

(5) Attempts have frequently been made to overcome the marked heterogeneity of field plots by correcting them on the basis of previous yields. An improved method allowing of valid error determinations that has recently been employed on annual crops, has been used on the uniformity trial data and gives substantial reductions in error which more than compensate for the extra time and labour involved in the recording of the previous yields.

The above findings helped in determining the design of the manurial experiment projected in *The Tea Quarterly*, May, 1930. The necessity of training a plucking team in the methods consistent with accurate experimental work suggested the expediency of accomplishing that training before the experiment proper was started. To this end, and as a means of deriving additional information, the experimental area was demarcated, and plucking records of each plot kept for the three months prior to pruning. The results of this preliminary trial will be best discussed after describing the design of the experiment.

Manurial Experiment:—The object of the experiment is to determine the response of tea to nitrogen and potash, separately and conjointly, and to obtain a comparison of the efficacy of three different forms of nitrogen in general use. The first question involves nine treatments which are summarised below. They comprise three levels of nitrogen and potash combined in all possible ways.

lb. N per acre	lb. K ₂ O per acre.		
	0	20	40
0	0,0	0,20	0,40
20	20,0	20,20	20,40
40	40,0	40,20	40,40

All plots have 30 lbs. P O per acre.

The plot size was standardised at 1/12 acre, being slightly larger than the optimum previously referred to, in order to provide an adequate supply of leaf for subsequent experimental manufacture.

The plots are replicated sixfold and are disposed over the field on the sites most suitable for experimental work in six blocks, each block containing each of the nine treatments referred to above in random order. There are thirty six plots receiving nitrogen. The three sources of nitrogen, sulphate of ammonia, cyanamide and bloodmeal are distributed over the whole experiment in an arrangement which provides that each combination of potash and nitrogen quantities has two representatives of each kind of nitrogen. Further, each kind of nitrogen balances out equally with respect to the quantitative interactions of potash and nitrogen; otherwise the arrangement is a random one.

The advantage of this seemingly complicated arrangement is twofold. In the first place it allows of valid errors being calculated, and it economises both land and time since every plot plays its part in answering the three questions outlined above.

With regard to the general scheme of cultivation, the usual practice of manuring alternate lines has been adhered to. The present meagre cover of dadaps has been lopped, evenly distributed over the manured rows, and the lines 'envelope' forked. The prunings are disposed over the alternate lines. In order to ensure an accurate distribution, the mixed manures were weighed out and bagged in quantities appropriate to each row.

Although the general replication is sixfold, questions relating to individual parts of the experimental programme are really more highly replicated. The extent of this replication and the errors of comparison in each case are shown in the following table. The calculations are based upon the preliminary trial before pruning.

	No. of Comparisons	Percentage S. E. of Difference	Significant Difference
Between different quantities of potash	18	7.27	14.83
Between different quantities of nitrogen	18		
Between different kinds of nitrogen	12	8.90	18.16

The errors are a good deal higher than might be wished. This is partly due to the fact that none of the old tea is eminently suitable for field experiments in spite of the fact that the best locations were chosen, and replication was employed up to the limit of the space available. The inherent weakness of the site cannot be remedied since the choice was between doing the experiment on the best land available or not at all. A further cause of high error is the fact that the field was already run out and in low condition when the preliminary yields were taken. There is however a reasonable possibility that careful pruning and particularly, careful plucking, will restore a modicum of uniformity to the area. Inspection of the field, a year after the previous pruning showed that what may be termed the 'ageing' of the bushes in the pruning cycle was more advanced than is normal; this can be rectified in the present cycle. Since these errors are perforce based upon a short time trial they should therefore be regarded as maximal errors. Taking them at face value the potash and nitrogen comparisons may be expected to show up even with these errors. On the other hand, the differences between

kinds of nitrogen, even if such differences were real, would, in all probability, be swamped by the attendant errors. There is at any rate a prospect of reducing the error and at least establishing a value which the alleged superiority of one or other of the nitrogenous manures is known not to exceed.

Drainage:—A small area on a regular and steep slope has had the ordinary drains converted into banded drains by means of concrete blocks. Time has had to be allowed for the joints between blocks and drain sides to fill up, and the area comprising 80 locks is now ready for completion and observation in heavy rain. During the course of construction a number of well defined paths have traversed the area. It is noticeable, even on casual inspection, that the run-off and transportation of soil into the locks has been greater on these areas where the soil has reached a state of compactness than on the rest of the area. This observation bears out the evidence given before the Soil Erosion Committee where attention was drawn to porosity of soil a factor in the prevention of erosion.

Cover Crops:—In response to the renewed interest in cover crops a series of nursery plots, each 1/100 acre in extent, has been laid down for studying the growth and suitability of a number of species. It has proved somewhat difficult to obtain all the species that were desirable, but from information derived from planting experience in Ceylon, from the Department of Agriculture and from the Tea Research Station in Java, fifteen varieties have been chosen.

The sowings were carried out between October 30th and Nov. 7th and have had to withstand a severe period of drought. They are consequently still at a very early stage of development which precludes any further report here.

The intention is to eliminate unsuitable species as a result of this preliminary trial, and to concentrate on promising species which can be grown on replicated plots and subjected to cultivation operations. Hand in hand with this, examination of the soil for any evidence of soil amelioration will be carried out.

The following are the species in process of testing:—

1. *Clitoria cajanifolia*
2. *Alylosia scarabaeoides*
3. *Tephrosia candida*
4. *Indigofera endecaphylla*
5. *Sesbania cannabina*
6. *Pycnospora hedysaroides*
7. *Indigofera arrecta*
8. *Tephrosia Vogelii*
9. *Cassia hirsuta*
10. *Crotalaria usaramoensis*
11. *Vigna sinensis*
12. *Calopogonium mucunoides*
13. *Pachyrhizus erosus*
14. *Pueraria phaseoloides*
15. *Phaseolus lunatus*

T. EDEN,
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REPORT OF THE BIOCHEMIST.

Staff:—Mr. B. N. Sastri, M.Sc., A.I.I.Sc., A.I.C., was appointed Research Assistant in the Department during the year, and commenced duties in July. Mr. Sastri proceeded direct to St. Coombs and was employed on various factory investigations in order to become acquainted with the practical details of manufacture.

Advisory:—163 letters were received and 121 letters were despatched. Many of the enquiries referred to details of withering installations, methods of rolling, types of humidifiers, taints in tea and the presence of white tips in tea.

Thirteen visits to estates in the Norwood, Maskeliya, Agras, Norton, Madulkelle and Haputale districts were made during the year to advise on tea manufacture generally, and to discuss and investigate the following points:—

- (1) Humidification and temperature control in factories.
- (2) Ventilation of rolling and fermenting rooms.
- (3) Withering installations.
- (4) Electrical drying of tea.
- (5) Taints in tea.

In addition to the publication of a series of articles on "Tea Fermentation" in *The Tea Quarterly*, the following lectures were given:—

"Withering" Dolosbage and Kotmale P.A.

"Some Factors in Tea Manufacture" Dickoya P.A.

Seasonal Variation in the Composition of Tea Leaf:—The analysis of the leaf from the experimental plots supplied by the Agricultural Chemist, and from plots to determine the effect of age of bush from pruning on the composition of the leaf were completed, but do not call for special comment at the present time since this work was dealt with in the 1929 report.

Factory Control and Investigation of the Various Processes Concerned:—It was not feasible to start controlled experiments in the factory since the Institute was stationed at Nuwara Eliya until near the end of the year and supervision of such experiments could not be satisfactorily arranged. It was, therefore, decided to make a study of the ordinary factory routine by collecting figures referring to the various processes. In this way the following data were collected:—

- (1) Weight of green leaf dealt with each day.
- (2) Weight of withered leaf dealt with each day.
- (3) Weight of fired tea obtained after each roll breaking.
- (4) Total weight of fired tea.
- (5) Moisture losses during each operation.
- (6) Percentage grades turned out, calculated on the weight of fired tea.
- (7) Rainfall.
- (8) Rolling Room temperatures (wet and dry).
- (9) Outside temperatures.
- (10) Loft temperatures.

(11) Total extract and moisture etc. of samples of B.O.P., B.P. and F.P. sent away with each break.

In addition to this a record has been kept since September, of the moisture content of samples of tea leaf as it comes into the factory each day, so as to determine the daily variation in the moisture content of the pluck, and to compare this with similar figures obtained for the out-turn of made tea on green leaf.

Information has also been collected as time and conditions permitted, of the air movements in the withering lofts, the uniformity with which the leaf withered on the tats under natural and artificial conditions, and the temperature conditions of the leaf coming out of the rollers.

Most of the data have been collected together in the form of a small handbook of factory information, and may be consulted therein but a few of these data will be further referred to in the present report.

YIELD, COMPOSITION OF CROP AND RAINFALL.

Yield:—The monthly yield of green leaf has been fairly even varying between 36,605 and 52,238 pounds, with the heaviest yield of 52,238 pounds in May. This represented the peak of the forced growth produced when the dry weather conditions of February and March became more suitable for growth as a result of wetter condition. This quick growth became noticeable in April with a rainfall of 6.12 inches against 3.73 inches in March, when the crop jumped from 38,444 to 41,942 pounds. The beginning of May was wet and very heavy precipitation occurred during the first fourteen days followed by a drier period favourable for good growth until definitely wet conditions set in during July. The results of the rains in May is seen in the increase crop to 52,238 pounds. The yield then dropped in June and reached a low level in July and did not again show any marked increase until November when the effect of the October rains was being felt. The monthly variation in the yield of leaf, therefore, was not very great during the year, but the variation for shorter periods is very much greater. Thus the variation of crop between breaks which are sent away every other week varied from 14,658 to 35,046, and the daily variation was greater still. There were several days on which no leaf at all entered the factory, and at other times the supply of leaf ran to 3,000 pounds. Although the year as a whole may be said to have produced a fairly uniform crop it will be seen that this is by no means true as far as the daily yield is concerned. Yield of crop and its variation is therefore an important factor to be considered when deciding the size of the factory on any estate. The ideal condition from the point of view of manufacture would be to have sufficient withering space and machinery available to deal with the biggest crop likely to be encountered on any one day, but the daily variation is so great that this is not economically possible. In the past, lack of factory space and machinery has been a limiting factor in successful tea manufacture since increase in crop production had overreached the capacity of the factories. Although larger factories are now the rule there does not appear to be any definite and generally accepted basis for computing the size of the factory required in relation to the yield of crop, number of days on which the factory will be fully working, interest on the extra capital sunk in extra machinery etc. and the gain as a result of improvement in the quality of the tea manufactured.

Composition of the Made Teas:—Break samples of the principal grades were taken before they were despatched, and analysed in the laboratory to determine the size of the particles forming the grades, percentage stalk in the grades, moisture, total extract, and tannin etc.

Particle Size of the Leaf Material in Grades:—This was determined by taking a quantity of the particular grade to be investigated and sifting it out in hand sieves with 3, 2, 1 m.m. and 100 meshes to the square centimetre for a definite time period. The various fractions were then weighed. At the same time the stalks were picked out by hand and weighed. The accompanying table gives some idea of the make-up of the different grades.

TABLE I.

Grade	Percentage failing to pass through sieves with meshes				Percentage Stalk.
	3 m.m.	2 m.m.	1 m.m.	100 to the Cm ²	
B.O.P.	0.0	6.4-25.6	67-82.5	6.4-11.0	9.3-17.2
B.P.	0.0	23.8-39.2	58.0-72.0	0.6-9.8	16.9-38.5
F.P.	23.0-35.9	53.5-63.7	6.5-11.6	0.2.0	—

67-82.5 per cent. of the B.O.P. consists of particles which pass a 2 m.m. mesh but fail to pass 1 m.m. mesh. The B.P. contains a little less of this fraction, but more particles which fail to pass a 2 m.m. mesh. There is a marked difference in the stalk content of B.O.P. and B.P., the stalk content of the B.P. being very high. This is greater than need be the case because no O.P. grade is turned out.

The Flowery Pekoe grade consists of much larger particles than the B.O.P. or B.P. since the bulk of the grade fails to pass through a 2 m.m. sieve, the greatest fraction being sifted out between the 3 and 2 m.m. meshes. Whereas B.O.P. and B.P. do not contain particles too great to pass a 3 m.m. sieve, 23-25.9 per cent. of the Pekoe may fail to pass the 3 m.m. mesh. Loose stalks as such were found to be almost absent in the Pekoe grade and the amount of dust was very small.

This separation of the grades was carried out to see whether it is possible or not to define any particular grade in terms of the size of particles composing it, so that grading in different factories may be compared. Data collected on the break samples have also been supplemented by determination on teas from other factories which have come to hand from time to time.

Moisture Content:—The results obtained show that there is a definite tendency for this to be higher during the wet weather than in the dry months. The greatest moisture content found in any sample was 8 per cent. in the October teas turned out during a wet period, and this must have been dangerously near the limit from the point of view of the keeping quality of the tea. During the dry weather periods of January-March teas sent for auction contained about 4.5 per cent. of moisture.

Total Extract:—The total extract from made teas varied in the same way as in the Dimbula teas reported on in the 1929 report. That is, a high extract was obtained from the January, February and March teas, although a decline was observed in March, and a further decline in April and May which reached its lowest point in May in exactly the same way as the teas already reported on. This lowest point corresponds with the lowest valuation obtained during the year. The total extract then increased slowly and irregularly from May to September but this increase was checked

by the wet weather in October, and then increased again in a characteristic way towards the end of the year. It is interesting to note how the total extract obtained from B.O.P., B.P. and F.P. compare with each other. According to market valuation these are generally placed in the following order: B.O.P., F.P. and B.P., but at times the F.P. has obtained a better price than B.O.P. The extracts obtained from the B.O.P. and F.P. were very nearly the same, but those from B.P. were much lower in keeping with the valuation for this grade. According to the analysis F.P. should be as good, if not better, than the B.O.P. and the liquors appeared to be better than those of the B.O.P. However, it must be remembered that F.P. is a big leaf grade and does not lend itself so easily as B.O.P. for blending purposes, and such considerations must be taken into account when the teas are being actually sold. The results bear out my previous contention that the total extract obtained is a good indication of the quality of the tea made provided the manufacture has been carefully carried out.

It was stated in the 1929 report that the total extract of fresh leaf varied inversely as the rainfall, and this is true of the made tea samples analysed during the year. The greatest effect of the rainfall however occurs when heavy rains are accompanied by a rapid growth such as occurred in April and May. Heavy rain in October did not have such a depressing effect on the extract.

Work Involved in Preparing the Made Tea:—The variation in the actual weight and the composition of the crop to be dealt with are not the only factors to be considered from the point of view of manufacture, since the work involved per pound of tea turned out is also variable, owing to the moisture on the leaf. It has been pointed out that the crop increased with the incidence of heavier rain in May and June, so that more work had to be done in the field and in the factory. This increase in the work to be done in the factory is very evident when the total weight of water and the weight of water per pound of made tea which must be driven off in the process of turning green leaf into tea are considered.

TABLE II.

Month	Rainfall	Average difference between W. & D. temperature at noon	Total weight of water evaporated lb.	Weight of water evaporated per pound of tea fired.		
				Total	In Wither	Drying
January	3.01	°F.				
February	2.52	12.9	27,477	3.00	1.96	1.04
March	3.73	12.2	28,263	2.77	1.77	1.00
April	6.12	9.5	31,997	3.22	2.08	1.14
May	13.27	8.0	40,308	3.38	2.12	1.26
June	10.53	4.8	33,046	3.54	2.47	1.07
July	5.82	5.8	28,169	3.30	2.19	1.11
August	8.24	6.0	29,963	3.44	2.41	1.03
September	10.85	—	30,010	3.31	2.29	1.02
October	16.30	—	30,373	3.47	2.41	1.06
November	5.61	7.9	33,553	3.50	2.33	1.17
December	0.94	10.1	27,085	2.97	1.96	1.01

Table (II) shows the total weight of water evaporated each month, the total weight per pound of tea fired as well as the weight of water

evaporated during withering and drying for each month. The average weight of water associated with each pound of tea each month thus varied between 2.77 and 3.54 pounds, thus showing a big difference in the energy required for simply evaporating water from the leaf. The daily variation is very much greater since this ranges between 2.50 and 4.60. It is, therefore, necessary at times to drive off as much water or more from the leaf during the process of withering as would be evaporated during the whole process of tea making in the dry weather. The crop may or may not be heavy at the same time, thus adding further to the actual amount of labour involved. Unfortunately, however, this increase in the actual amount of water to be evaporated from the leaf is also accompanied by less satisfactory drying conditions, especially as regards withering. The difference between the wet and dry bulb temperatures is a good indication of the drying power of the air, and on reference to these figures in Table (II) it will be found that the months producing leaf with a high moisture show the least difference between the wet and dry bulb. It is no wonder therefore that it is more difficult to produce good quality tea during the wet periods owing to the following facts:—

- (1) Poorer quality in the crop harvested.
- (2) Increase in work necessary to wither the leaf.
- (3) Decrease in the drying efficiency of the atmosphere at the very time when more efficient drying is necessary.

At the same time this must not be taken as an excuse for producing poor teas during this period, since with modern conveniences it is possible to overcome the difficulty arising from the second and third factors. It is just as well, however, to bear in mind that in spite of overcoming the second and third factors, the first limiting factor still persists, and that the same quality tea is hardly to be expected during the wet season as during the dry season. The season for this must be ascribed to a difference in the quality of the leaf and not to the effect of using conditioned air. The only true comparison of the benefit of using proper withering schemes against very slow natural withering is to compare the teas produced with and without conditioned air, and also to take into consideration the improvement in the possibility of having the leaf ready for rolling according to programme instead of having to delay the work while waiting for the leaf to be ready.

The total quantity of water associated with each pound of made tea thus varies, and the question arises as to how this varying moisture affects the process of withering and firing apart from the total work to be done in evaporating it. If a constant degree of wither is arrived at then the variation is shared between the withering and firing processes, so that the withered leaf will contain varying amounts of water going to the rollers each day, and firing conditions will vary accordingly although the routine of the process may not be altered. This is sure to result in irregular firing from day to day, while the leaf sap pressed out in the rolling will vary in concentration day by day, and thus alter the fermentation. The effect of withering the leaf to the same degree each day on the moisture content of the rolled leaf and thus on the work involved in drying can be seen from Table III where these figures have been calculated from the monthly crop on the basis of a 50% wither.

TABLE III.

Variation in the amount of water lost per pound of fired Tea on drying when a constant wither of 50% is obtained.

Month	Percentage moisture in withered leaf	Pounds of water driven off per lb. of tea fired
February	50.0	1.00
March	46.0	0.86
April	52.6	1.11
May	54.5	1.20
June	56.1	1.28
July	53.4	1.14
August	55.4	1.23
September	53.8	1.16
October	55.5	1.24
November	56.0	1.36
December	49.7	0.99

Withering to a constant loss of weight of the fresh leaf thus results in a variation between 0.86-1.36 pounds in the average weight of water to be evaporated in the dryers per pound of fired tea, whereas if the leaf was withered down until it contained the same moisture content each time, the amount of water lost per pound of tea in the dryers should be constant. In actual practice where the withered leaf was removed to the rollers when it was considered ready, the range of variation was between 1.00 and 1.26. The higher figure was only reached for one month, so that the irregular condition of the leaf was evened off in the wither, thus giving more uniform material for rolling, withering and drying. The effect is more marked still when individual days are considered. Thus on one day in June the weight of fresh leaf was 1313 pounds while the weight of fired tea was only 234 pounds. If this leaf had been withered to a 50 per cent. loss it would have been necessary to drive off 1.80 pounds of water for every pound of dry tea in the dryer, and the withered leaf would have contained 64.3 per cent. of moisture. In actual practice this leaf was withered down to 38.5 per cent. of the weight of the fresh leaf so that only 1.16 pounds of water had to be driven off in the dryer per pound of dry tea.

It may not be possible to attain perfection in actual practice but a good deal can be done towards this by adopting the policy of withering the leaf until it attains the same condition each time and not withering to a constant loss of weight. If the policy of withering to a constant loss of weight is adopted, then there will be no uniformity in the material used for the manufacture.

Changes Observed in the Reaction of Fresh Leaf During Withering:—

Reporting on Chemical Wither in *The Tea Quarterly*, 1928, 4, I suggested that the effect of time on the wither can be explained on the hypothesis that the drying causes a concentration of the cell sap, so that the degree of dispersion of the cell constituents is altered. The increase in concentration thus affects the physical condition of the colloidal material of the leaf, with consequent changes in the permeability and the surface area of the protoplasm, which are of great importance for cell oxidative processes. Since then, observations of the changes in withering leaf

have been made from time to time as the press of other work allowed, and recent experiments support the contention that withering is accompanied by quite well-defined changes other than loss of moisture.

When fresh leaf is allowed to stand covered with water for a period of 24 hours some of the leaf material is leached out; but when withered leaf is covered with water in this way, the amount of substance which can be leached out of the leaf is considerably increased. The leachings obtained from fresh leaf were of a light yellow colour, but on standing the colour deepened to a deep yellow. The leachings from withered leaf were a beautiful golden colour, and all the leachings gave a positive reaction for tannin. During the leaching some of the leaves turned brown in patches, and some of the leaves became transparent while showing dark coloured patches distributed within the leaf. The nature of the change in the amount of leached material obtained from the leaf in various degrees of withering can be gleaned from the following data:—

TABLE IV.

Leachings Obtained from Fresh and Withered Leaf.

Percentage dry weight of leaf.		Degree of wither		Percentage dry matter in leachings.
25.3	...	Fresh leaf	...	5.3
26.3	...	93	...	4.3
29.5	...	88	...	5.2
32.0	...	84	...	6.1
33.3	...	74	...	7.6
36.4	...	70	...	9.0
39.1	...	66	...	10.3
44.5	...	60	...	12.9
45.2	...	57	...	13.4
60.0	...	45	...	16.9
79.0	...	31	...	23.6

The fraction which can be leached out from the leaf does not show much change until the leaf has withered down to about 80% but on further withering a rapid change occurs and this becomes very rapid when the leaf is withered between 66 and 57 per cent., which is in the region arrived at for a good wither in Ceylon. By withering the leaf down to 55 or 50 per cent. it is quite certain that the region of rapid change has been attained and the benefit of withering for the subsequent changes is ensured. The increase in leached material is not due to hydrolysis of some of the insoluble material of the leaf to form simpler and more soluble bodies, since it has been shown in other experiments that the increase is the result of the loss of moisture from the leaf and not the result of time. If the leaf is kept under cover so as to prevent the loss of moisture the amount of leached material decreases as a result of respiration of the leaf and if this leaf which has been kept from withering is then allowed to wither, an increase in the leached material takes place as it withers, but the total amount of leached material obtained when this leaf is withered is never so high as with leaf wither in the normal way. This can be seen from the results obtained,

Percentage dry matter leached from fresh leaf = 4.7

kept " under cover " for 24 " hours. " } = 2.1

Percentage dry matter leached from samples
of the same leaf withered directly = 14.7

Percentage dry matter leached from leaf kept
under cover and then withered = 7.0

Further, if the leaf is allowed to wither slowly as sometimes occurs during periods of high humidities there is little or no increase in the amount of material leached from the leaf by water, since leaf withered in 48 hours only lost 7.4 per cent. of its dry matter on being treated. The rate of withering does, therefore, appear to play an important part in controlling the chemical or physical changes which take place during withering. The significance of these changes is not quite clear as yet, but the results show that the withering of the leaf is accompanied by definite changes other than the loss of moisture and that these transformations can be easily measured. The changes observed are not of the order of a few degrees per cent, but between 200 and 300 per cent, so that there is no question of the observed differences being due a sampling errors. Although, it is certain that a very slow wither produces different results from a normal wither in 18-24 hours, results under conditions which produce a very quick wither have not yet been obtained. If a quick wither is brought about artificially by means of dry air under a low pressure, the leaf simply dries out without becoming pliable, and the result is hard, badly discoloured leaf which is entirely useless for any further treatment.

The results obtained indicate that the actual amount of material which can be leached out of the fresh leaf itself varies according to the conditions of growth, thus leaf harvested in the dry weather lost 8.0 per cent. of its dry matter, while leaf harvested after a period of wet weather lost only about 3 per cent. of its dry matter when leached, and leaf brought in later after a short period of fine weather lost about 5 per cent. of its dry matter. These results are very interesting and promise to throw some light on the question of quality of leaf and withering, but further work is necessary to determine what is the connection between the degrees of wither, manner of withering and the leaching effect. The relations can be best studied in connection with factory experiments designed to test out the effect of withering not only on the quality of the tea but also on the various processes involved in the manufacture.

Effect of Rolling on the Withered Leaf:—The process of rolling the withered leaf consists in twisting the leaf under varying degrees of pressure so that the leaf is crushed, sap is expressed, and the leaf is broken up. During the roll breaking and sifting, the finer portions are removed from the coarser particles, the actual amount separated out depending on the manner of rolling carried out, and the care given to roll breaking. Not only does the amount depend on the rolling, but the way in which the separated fractions are made up also varies, i.e., the pluck does not always break up in the same way so that the nature of the leaf put out to ferment after each roll varies according to the rolling programme, and is therefore a variable factor in fermentation. Since the actual shearing effect of the rolling is a purely mechanical one, its effect is best measured in a mechanical way by examination of the leaf after rolling for twist and separating

out the various parts composing the mass of rolled leaf. The investigation of the mass of rolled leaf has been carried out by picking out the stalks, tips, and leaf from the bulk and weighing the different portions, and then by further examining the size of the various particles present after rolling the leaf by sifting out the various sized particles in the same way as was done with the tea grades. The distribution of the particles in the various dhools remains fairly constant since the mesh of the green leaf sifter seems to be the deciding factor. A measurement of the actual percentage of dhools separated out is therefore a good criterion of the mechanical effect of rolling, apart from the separation of tip and stalk which can be determined by picking. A few determinations have also been carried out on the differential effect of heavy and light rolling on the break up of the leaf and also on the temperature rise which takes place as a result of the fermentation of the leaf and the friction set up. These observations which must be carried out for some time have shown that the amount of pressure applied in the rollers not only affects the break up of the leaf, and the temperature of the leaf in a marked degree, but also the subsequent fermentation of the leaf. It is not quite clear whether this is due to a greater crushing effect, or higher temperature conditions in the rollers, since the variation in pressure produces entirely different conditions of manufacture. Thus although very heavy pressure in the first few rolls may produce a high temperature it also ensures that a very high percentage of the leaf is quickly removed from the seat of high temperature to the cool fermentation conditions of the rolling room, while a uniform condition of fermentation has been set up in the leaf separated. On the other hand light pressure does not result in such high temperatures in the rollers, but it produces a gradually increasing fermentation as more leaf gets crushed and, since the amount separated in the first dhools is so small, it means that the bulk of the leaf is fermenting at a comparatively high temperature for a long period. The question of pressure on the rolled leaf is thus a complicated one and it is necessary to withhold conclusions of the interplay of the factors concerned until the matter has been more closely studied..

The Chemistry of the Tea Leaf:—The observations on manufacture have been supplemented by chemical analysis in many instances, and at the same time work has been carried out on the tannin of the leaf. The small amount of tannin which can be separated by means of the method described by Deuss for preparing tea tannin suggests that the small yield obtained was not entirely due to losses during the preparation, but that the tannin obtained in this way only represented a very small fraction of the tannin bodies present in the leaf. The tannin isolated by Duess was soluble in dry ethyl acetate, and yet when dry leaf is extracted with this solvent the fraction removed only represents 6·8% of the leaf, whereas the tannin estimated in an aqueous extract of the same leaf amounts to 18-20 per cent. or more. Extraction with acetone gives similar results, and extraction with various strengths of alcohol seems to result in a fractionation of the tannin bodies. When dried fresh leaf is extracted with water and this is concentrated, a fractional precipitation of the soluble material is obtained on adding alcohol, and several fractions have been prepared in this way. The precipitates obtained, however, are very impure owing to co-precipitation of various substances from the solution, and further work shows that the extract of fresh tea leaf, is very unstable and that changes

had been produced during the evaporation of the extract, although this had been carried out under the best vacuum possible in the laboratory. Further investigation along this line was therefore postponed until suitable conditions for such work could be obtained in the new laboratories.

In the meantime Shaw (Tannin Principles of Tea Pt. 1 1930) published an account of his researches on the tannin principles of tea, describing a method of preparing tea tannin and a modified iodimetric method of estimating the tannin in fresh leaf. Shaw does not give any idea of the yield of his preparation although this is a test of any method of preparation and repetition of his work shows this to be of a very low order. Further, it can be shown that only a small fraction of the tannin present in the fresh leaf can be extracted by a saturated salt solution and that the greatest fraction of the total oxidisable material extracted by water is precipitated on saturating with salt. Although the actual partition of salt soluble and salt insoluble tannin can be altered by various treatments such as drying the leaf, it is certain that a salt insoluble fraction giving tannin reactions exists in fresh leaf and that the presence of this tannin affects the oxidation of the salt soluble tannin. The work reported by Shaw is being repeated so as to confirm his results. Several interesting points have been found, and these have necessitated a certain amount of side tracking from the main investigation which is being continued.

Experimental Machinery:—Attention was also given during the year to the design of experimental machinery, and these designs have been described in *The Tea Quarterly*. Two small rollers arrived from England towards the end of the year and work was well advanced on the roll breaker and dryer, but it was not possible to try out the machinery for manufacturing purposes during the year under review.

D. I. EVANS.

Biochemist.

TEA RESEARCH INSTITUTE OF CEYLON.

BALANCE SHEET AS AT 31ST DECEMBER, 1930.

LIABILITIES.		ASSETS.	
GOVERNMENT OF CEYLON :—		PROPERTY :—	
Loan @ 6% per annum secured by Mortgage	Rs. 1,000,000-00	At St. Coombs Estate at 31st December, 1929	Rs. 663,925-45
Less Repayments	" 37,547-72	Expenditure 1930	" 27,261-18
	" 962,452-28	BUILDINGS, FURNITURE, LINES, ETC :—	
Add Accrued Interest	" 14,436-78	At 31st December, 1929	" 233,567-80
	" 43,628-61	Expenditure 1930	" 473,095-59
SUNDRY CREDITORS :—		MACHINERY AND TOOLS :—	
As per Schedule (since paid) Jeremiah Lyon & Co. £11.12.9 @ 1/6	" 155-16	At 31st December, 1929	" 99,642-27
	" 43,788-77	Expenditure 1930	" 68-40
RESERVE FOR DEPRECIATION	22,659-00	EXPERIMENTAL MACHINERY	
SURPLUS ACCOUNT :—		ESTATE SUPERINTENDENT'S ACCOUNT CURRENT	
At 31st December, 1929	" 504,934-47	CEYLON ASSOCIATION IN LONDON £216.3.6 @ 1/6	
Excess of Income over Expenditure	" 51,514-79	SUNDRY DEBTORS :—	
		Research Staff	Rs. 801-66
		Sundries	" 139-54
		Col. Treasurer Tea Cess (Decr.)	" 15,102-04
		Forbes & Walker last Inv. (25)	" 6,568-15
		Empire Marketing Board £1,000/- claimable amount	" 3,111-56
		CASH :—	
		At Banks	67,317-68
		In Hand	" 135-19
			<u>Rs. 1,599,781-09</u>

We have audited the books of the Institute kept by the Planters' Association at Kandy, in which are incorporated the Estate Returns. We have not audited the Estate Accounts.

Subject to the foregoing, in our opinion, the above Balance Sheet is a full and fair statement properly drawn up so as to exhibit a true and correct view of the state of the Institute's affairs as shown by the books of the Institute kept at Kandy.

Colombo, 26th February, 1931.

FORD, RHODES, THORNTON & Co., } Auditors.
Chartered Accountants.

TEA RESEARCH INSTITUTE OF CEYLON.

Dr. ESTATE WORKING ACCOUNT FOR THE YEAR ENDED 31ST DECEMBER, 1930. Cr.

EXPENDITURE		INCOME	
	Rs. Cts.		Rs. Cts.
To ESTATE REVENUE EXPENDITURE ...	82,106-45	By TEA SALES 112,208 lbs.	Rs. 128,484-14
" ESTATE CHARGES EXPORT DUTY, ETC. ...	6,563-39	" INFERIOR TEAS 3,185 "	952-80
" BALANCE CARRIED TO INCOME AND EXPENDITURE ACCOUNT ...	40,767-10		
	<u>Rs. 129,436-94</u>		<u>Rs. 129,436-94</u>

Dr. INCOME AND EXPENDITURE FOR THE YEAR ENDED 31ST DECEMBER, 1930. Cr.

To RESEARCH REVENUE EXPENDITURE:—		By BALANCE FROM ESTATE WORKING ACCOUNT	
	Rs. Cts.		Rs. Cts.
ADMINISTRATION OF THE BOARD:—	6,000-00	TEA CESS ...	40,767-10
Planters' Association of Ceylon	3,400-00	" INTEREST ...	243,548-62
Secretary (Salary) including Bonus ...	1,971-25	" GRANT FROM EMPIRE MARKETING BOARD:—	7,891-69
Travelling Expenses of Board	217-73	(£1000) Claimable Amount ...	3,111-56
Postages ...	551-48		
Stationery ...	628-89		
Advertising ...	78-31		
Telephone, Trunk Calls, Telegraphic Address	540-88		
Telegrams, Commission, Cables, etc. ...	172-80		
Printing ...	644-65		
Legal Charges ...	334-06		
Auditors' Fee and Expenses	10-45		
Cart Hire and Sundry Expenses	14,550-50		
	<u>Carried over</u>		<u>Carried over</u>

TEA RESEARCH INSTITUTE OF CEYLON.

Dr. INCOME AND EXPENDITURE FOR THE YEAR ENDED 31ST DECEMBER, 1930.—(Contd.) Cr.Rs. Cts.
295,318-97

Brought forward

Rs. Cts.
14,550-50

PERSONAL EMOLUMENTS OF SCIENTIFIC STAFF :—

Director	20,540-32
Mycologist	16,050-00
Biochemist	12,660-00
Agricultural Chemist	12,722-58
Entomologist	12,037-09
Plant Physiologist	8,583-34
House Allowances	8,072-40

90,665-73

LABORATORIES :—

Sub. Staff Salaries	Rs. Cts. 6,407-70
Lab. Peons	888-81
Rent and Taxes	3,990-45
Insurance	42-50
Equipment	16,432-86
Furniture and Alterations	1,005-32
Library	1,394-97
Publications	1,407-61
Sub. Staff House Allowance	514-83
Sub. Staff Stn. Allowance	347-13
Nettle Grub	3,648-57

36,080-75

Carried Over

Rs. 141,296-98

Carried Over

Rs. 295,318-97



